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The Atlantic Salmon Resource of the North River, Victoria County, N.S. to 1984

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by

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ABSTRACT

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The biological status of the Atlantic salmon resource of North River, Victoria County, and the impact of harvests on the stock prior to 1984 are documented. An estimated salmon production area of $3,559*10^2$ m^2 and documented stock composition indicate that 137 to 195 multi-sea-winter salmon and 23 to 32 one sea-winter grilse are required to achieve egg deposition rates of 1.7 and 2.4 eggs m^{-2}. Historical estimated escapements have been less than this requirement. Management strategies to alleviate the paucity of spawners, including curtailment of local commercial fisheries and restrictions of the sport fishery, are examined.

RÉSUMÉ

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On traite ici de la condition biologique du stock de saumon de l'Atlantique de la rivière North, comté de Victoria et des effets qu'ont eu sur lui les récoltes avant 1984. Considérant une surface de production estimée de $3\ 559*10^2$ m^2 et les données attestées sur la composition du stock, il faut de 137 à 195 redibermarins et de 23 à 32 unibermarins pour obtenir un taux de distribution d'oeufs de 1,7 et de 2,4 oeufs par m^{-2}. Or, les échappements antérieurs estimés ont été inférieurs à ces chiffres. On examine également les stratégies de gestion adoptées pour lutter contre la pénurie de reproducteurs, notamment la réduction de la pêche commerciale et les restrictions sur la pêche sportive.

INTRODUCTION

The North River, Victoria County, Cape Breton Island, is an important producer of Atlantic salmon (Salmo salar). The salmon stock is both early-run and two-sea-winter in composition, a characteristic which is currently scarce on the island. Historic exploitation by commercial and sport fisheries has contributed to concerns about the status and management of the North River stock.

This document summarizes and analyzes data relevant to setting and achieving target spawning escapement in the North River prior to and exclusive of the 1984 Salmon Management Plan.

NORTH RIVER BASIN

North River, Victoria County, lies on the eastern slope of the Cape Breton Highlands (Fig. 1). The watershed is approximately 230 km^2 and abuts the drainages of the Baddeck, Middle, Margaree and Barachois rivers. The Middle Branch, North River, arises in the Highlands at an elevation of 1450 m and travels some 29.9 km to St. Ann's Harbour.

Generally the main river and most of its branches have a bottom composed of predominantly granite rock ledges, boulders and coarse gravel (Smith and Ingram, MS 1954). Gradients are steep (Fig. 2 and Tables 1) with many small falls, two of which are known to be complete barriers to upstream fish passage. One barrier is on the East Branch about 3.5 km from its confluence and one is on Timber Brook about 1.0 km from the confluence with the main river.

Water quality is pristine and is unstained by organic acids or oxides of iron. Water temperatures and discharge are not monitored but are assumed to be similar to those of the Northeast Margaree. Conductivities of water sampled during electrofishing activities ranged 51-73 s cm^{-1} at 20°C and are therefore not greatly influenced by anhydrite deposits common to the general region.

METHODS

Biological materials from the sport and commercial fisheries were collected by staff of the Conservation and Protection (C&P) Division, Fisheries Operations Branch, Dept. of Fisheries and Oceans, Baddeck, N.S. Catch and effort data for the sport fishery were collected by C&P and reported by Smith (1981) and Swetnam and O'Neil (1984). Commercial landings and effort for Fishery Statistical Districts (FSD) Nos. 1 and 4 were collected by C&P up to

1979 and from mandatory logbook reports to 1983 and reported by Alan and Lindsay (1967) and in Redbooks[1].

Estimates of salmon production area and gradients were derived with the aid of orthophotographic maps (Scale 1:10,000), and aerial photographs to measure widths similar to Amiro et al. 1989. Obstructions and a general description of the substrate are documented by Smith and Ingram (1954).

Electrofishing was conducted for the purpose of estimating the abundance of juvenile salmon in selected sites on August 16, 17, and 25, 1978. Data were collected according to the method of Elson (1967) with the addition of recording the length of each fish captured. Estimated fish densities within the sites were derived using the method of Junge and Libosvarsky (1965) for three sweeps and Zippin (1956) for four or more sweeps.

Smears of kidney tissue from both North River sport-caught fish and St. Ann's Harbour commercial-caught salmon, 1978, were submitted to the Fish Health Unit, Fisheries Research Branch, Halifax Laboratory. Detection of the bacteria Corynebacterium sp. (bacterial kidney disease) was achieved by the indirect fluorescent antibody technique (IFAT) of Bullock and Stuckey (1975).

Records of hatchery introductions of salmon were obtained from files of the Margaree Fish Culture Station and Annual Reports of the Resource Development and Fish Culture branches. Dr. P.F. Elson, formerly of the St. Andrews Biological Station provided tagging data from hatchery-reared smolts released into the North River in 1961.

Scale samples were examined at least twice by one of us (Amiro). Those from 1973 were also read by R.F. Burfitt, formerly with the Fisheries Research Branch, St. John's, Nfld.

The number of spawners required to seed the North River was calculated by dividing the product of required egg deposition rate, 1.7 to 2.4 eggs m^{-2} (Elson 1975), and the estimated production area by the calculated egg deposition per fish. A fecundity of 1343 egg kg^{-1} was derived from eleven 2SW fish and one 2+SW fish collected for broodstock in 1983. The average egg deposition per 1SW and MSW spawner was calculated from sport fishery data as the product of eggs kg^{-1}, proportion female, mean weight and proportion sea-age.

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[1]Atlantic Salmon Commercial Catch Statistics, Maritime Provinces, annual series beginning in 1967. Published by Dept. Fish. and Oceans.

RESULTS AND DISCUSSION

SALMON PRODUCTION AREA

Detailed estimates of quantity and quality of substrate are unavailable. A general survey by Smith and Ingram (1954) noted that the North River had "... very few good salmon spawning areas" and "... the few small suitable spawning areas are scattered throughout most of the length of the main river and its three branches". Rearing area by the remote survey method (Table 1) was estimated to be 3,559 10^2 m^2.

JUVENILE PRODUCTION

Quantitative electrofishing was conducted at three sites on the main river in 1978 (Fig. 3). The two sites below the gorge had an average density of 21.8 salmon fry $unit^{-1}$ (10^2 m^2). The upper site had a density of 107.5 salmon fry $unit^{-1}$ (Table 2). Average salmon parr densities (1+ and older) below the gorge were 9.2 $unit^{-1}$. Comparable densities above and below the gorge were 32.2 $unit^{-1}$.

Age-0+ densities of brook trout (Salvelinus fontinalis) were 0.5 and 1.9 $unit^{-1}$ above and below the gorge respectively. Eel (Anguilla rostrata) densities (almost entirely small i.e.,<10.0cm fish) averaged 38.8 $unit^{-1}$ below the gorge. Above the gorge they were so few as to be unquantifiable.

Percentage composition of age 1+, 2+ and 3+ parr above and below the gorge were 80:20:0 and 82:15:3, respectively. The absence of 3+ parr above the gorge may reflect a shortcoming of the sampling.

Salmon fry and age 1+ parr densities above the gorge were much higher than Elson's (1967) "index of normal abundance" of 24 and 20 10^{-2} yd^2 (28.7 and 23.9 $unit^{-1}$) for fry and small parr respectively in New Brunswick rivers. High densities above the gorge may be inflated because of site proximity to MacLean's and MacLeod's pools which are major adult holding areas and are likely near spawning locations.

INFLUENCE OF FISH CULTURE PROGRAMS

The introduction of salmon to the North River began in June 1894 (Fig. 4) with liberation of fry reared from eggs held at the Sydney Hatchery. Fish released between 1903 and 1972 were mostly reared at the Margaree Fish Culture Station. Some yearlings and smolts released between 1965 and 1968 were reared at the Saint John, Yarmouth or Mersey fish culture stations.

Although some of the older stocking records have been omitted from key references, it is apparent that at least 854,400 fry (released approximately two weeks after complete absorption of the yolk sac) and 3,760,900 fingerlings (from 26 weeks to 1 year from date of hatch) were liberated into the North River. Yearling (from one year after date of hatch) and smolt (two years after date of hatch) releases 1965-1983 have totalled 22,780 and 52,198, respectively. None of the hatchery-liberated fish were of North River parentage, but rather were of Miramichi, Saint John, Margaree, Morell rivers or Bay Chaleur origins.

Tagged smolt releases in 1967 (4,993 Margaree stock, Margaree and Yarmouth-reared) and 1968 (4,839 Bay Chaleur stock, reared at Coldbrook FCS) totalled 9,772 fish. Adult recaptures were scarce with neither the Nova Scotia commercial fishery nor the sport fishery reporting any tags. Potential reasons for the poor performances ranged from aggravated disease problems, timing of release, difference between pre-release and release water temperatures, and stock selection.

Stocking of hatchery salmon fry into streams containing moderate native juvenile populations is currently considered to be unproductive. It is likely that fry releases into the North River were under-distributed (due to access and logistics required to distribute at this early juvenile stage), excessive (with respect to the unoccupied nursery habitat) and perhaps an inferior product (due to the culling process of selecting larger fish for rearing to the fingerling stage). Hence, adult returns from stocking of fry are expected to be insignificant under these conditions.

Fingerlings were stocked between 1928 and 1971 at more than four times the numbers of fry. By virtue of hatchery grading practices and the size at distribution, fingerling survival is expected to be greater than for fry. While a deterministic assessment of the effectiveness of the fingerling stockings is not possible, estimates of their contribution to the sport fishery can be deduced from catch and catch per unit effort (CPUE) data.

Utilizing catch and effort data, 1956 to 1971, and the number of fingerlings released from 1951 to 1971, we calculated a series of correlation coefficients of catch and CPUE in years n+4 and n+5 on numbers of fingerlings released in year n. While no significant ($p=0.05$) correlation was found between total catch in year n+4 and fingerlings stocking in year n, a highly significant relationship ($r=0.86$; $p < 0.01$) was found between CPUE in year n+4 and number of fingerlings stocked in year n. This result suggests that improved CPUE for 2SW salmon may have been a result of stocked fingerlings which smoltified at age 2.

This deduction is supported by the lack of a significant correlation between total catch of 2SW salmon on the North River and total catch of MSW fish on the Margaree River (r=0.12), the principal donor stock; and the absence of a significant correlation between CPUE for salmon for all rivers of Cape Breton Island and the CPUE for North River (r=-0.26) 1956-1971.

KIDNEY DISEASE

The presence of bacterial kidney disease (BKD) among juvenile salmon and brook trout of the North River drainage was first confirmed from a sample of 18 fish electroseined from Tarbotvale Brook in 1977 (Paterson, pers. comm.)[2]. The incidence of BKD was 27.8 percent. Kidney smears taken from 34 adult salmon caught in the sport fishery between June 20 and September 22, 1978 had an incidence of 5.9 percent. A sample of 55 smears taken from the commercial fishery in St. Ann's Harbour between June 6-22, 1978 had an incidence of 20 percent IFAT positive.

Bacterial kidney disease was found in collections of all juvenile salmonids sampled from major rivers of Victoria and Inverness counties in 1977 (Paterson et al., 1979). The incidence was 37.5 percent (n=304) for the Margaree River, 23.8 percent (n=21) for the Cheticamp River, 17.6 percent (n=17) for the Middle River and 57.7 percent (n=26) for the Baddéck River. Respective percent incidences for Atlantic salmon parr were 40.6 (n=207), 15.4 (n=13), 0.0 (n=10) and 57.7 (n=26). Samples of 313 salmon parr from 17 rivers of mainland Nova Scotia, 1978, exhibited a 3.5 percent incidence of BKD (Campbell, pers. comm.)[3].

Paterson et al. (1979) reported the incidence of BKD in live Margaree River adult salmon to be 37.5 percent (n=24) in 1977. Marshall (MS 1982) presented data for the incidence among four separate collections of wild smolts descending the Margaree 1976; the unweighted average incidence for 227 samples was 70.5 percent. If the incidence among resultant returning adults (1SW, 1977; 2SW 1978 etc.) was the same in 1978, i.e., 37.5 percent, then balancing smolt and adult incidences of BKD-carrier:BKD-free, would indicate a 52.8 percent loss of the river's smolt output associated with positive IFAT's. While there are no similar data for the North River, the finding of BKD organisms in that salmon stock portends smolt-to-adult survival rates lower than in disease-free stocks.

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[2] W.D. Paterson, Aqua Health Ltd., West Royalty Industrial Park, Charlottetown, P.E.I., C1E 1B0

[3] M.I. Campbell, Fisheries and Oceans, P.O. Box 5030, Moncton, N.B. E1C 9B6

COMMERCIAL FISHERIES

No specific data on commercial exploitation of the North River stock has been collected outside of St. Ann's Harbour, but it is likely that the proportion of North River fish taken in Fishery Statistical District (FSD) Nos. 1 and 4 increases with proximity to the harbour and the river.

Catch statistics for salmon from FSD No. 4 since 1949 have ranged from a high in 1950 of 24,200 lbs (10,976 kg) to a low in 1972 of 2,000 lbs (907 kg) (Fig. 5). Low catches, 1955-1960 and 1971-1973, were experienced throughout the Maritime Provinces. The number of salmon traps in FSD No. 4 declined erratically from 40 in 1953 to 13 in 1983. Sea-fish traps, or commercial fish (herring) traps, legitimately set for non-salmon species but which took a considerable by-catch of salmon numbered as high as 12 in 1966. Two were located within St. Ann's Bay - one being set early in June. Three mackerel trap nets and two squid trap nets prosecute an August fishery within St. Ann's Harbour.

Landings in St. Ann's Harbour, and their contribution to the total landings of FSD No. 4, are illustrated in Fig. 5. The number of licensed salmon traps fishing there has ranged from 13 in 1950 to three in 1960. In 1983, five salmon traps fished in St. Ann's Bay. Catch per trap for St. Ann's Harbour was higher for the period 1978-1981, than anytime between 1949 and 1968 (Fig. 5). The peak values of approximately 1,200 lb net^{-1} (544 kg net^{-1}) for the later period are coincident with increased catches in all FSD's during this period and with a decline in fishing effort outside St. Ann's Harbour. The 1982 and 1983 catch (lb net^{-1} values of 333 (151 kg) and 246 (112 kg), respectively, paralleled general declines in all commercial salmon landings but are not low compared to historic catches. Also, total catches in St. Ann's Harbour were not low compared to historical low catches. This observation suggests that effective exploitation of stocks within St. Ann's Harbour has not declined in spite of the reduced fishing effort both within and outside St. Ann's Harbour. Daily landings, 1980-1983, and weekly landings, 1980-1983, adjusted to a 1983 base, of salmon in St. Ann's Harbour indicate that nearly 80 percent of the fish were taken in June (Fig. 6).

Scales taken from 12 and 79 salmon captured commercially in St. Ann's Harbour, 1975 and 1978 respectively, revealed that most fish had spent three years in freshwater (71.4 percent), and two years at sea (85.7 percent) and that 86.8 percent were females (Table 3). The selectivity of salmon traps of 5-1/2- inch mesh resulted in a sample which, with one exception, was comprised of 2SW or older fish. Salmon spending three years in fresh and two years in salt water (age 3.2) comprised 67.0 percent of the sample (Table 4).

Salmon aged 2.2 and 2.3 were next most abundant at 14.3 percent and 7.7 percent respectively.

No direct evidence linked catches to the river origin of stocks harvested within St. Ann's Harbour, but a statistical procedure using scale samples from the North River sport fishery and the St. Ann's Harbour commercial fishery in 1978 indicated that 79 to 88 percent of the commercial fish sampled in 1978 was North River-like fish (Reddin and Misra, 1985).

Smolt tagging programs carried out by various branches of the Department of Fisheries, 1958-1984, outside North River have yielded 18 tags from adults captured in St. Ann's Harbour. Nine of these fish were tagged as native or hatchery-reared smolts released into the Northwest Miramichi River, 1958-1972, and represented 0.05% of all adult recaptures from Miramichi releases. The remaining nine recaptures occurred between 1970 and 1984. Six of these were from smolts of Miramichi stock raised at Cobequid FCS and released into Middle River, Victoria County. Two of the recaptures were of Bay of Chaleur (or Restigouche) stock released into the Miramichi and Margaree, a stock generally noted for its straying and poor return rate. One tag reported recaptured in 1972 originated from a smolt tagged at the Kejimkujik FCS and released into the Medway River, Queens Co., in 1971.

SPORT FISHERY

Sport fishery statistics are used to infer abundances of North River salmon in the absence of a fishway or trapping facility. Catch statistics for the North River sport fishery began in 1929, and catches first peaked at 349 fish in 1938 (Fig. 7 and Table 5) and secondly in 1952 at 356 fish. The slowly increasing recorded catch between 1929 and 1934 likely reflects the difficulties in initiation of a reporting system and/or increasing effort. With the exception of 1952, catches slowly but significantly ($p < 0.005$) declined from 1938 to 1966. Thereafter catches increased until 1970 from whence there has been no significant ($p < 0.05$) trend. Mean annual catches (Table 6) for the periods 1929-1938, 1938-1966, 1966-1970, and 1970-1983 reflect general trends shown in Fig. 7. The mean catch for 1970-1983 compared to mean catches of the earlier periods indicate that partial closures, 1975-1983, did not reduce catches significantly (Table 6).

Duration of the sport fishery and opening and closing dates have varied over the years. The 1973-1983 seasons opened on June 1 and closed September 30. Previous to 1973 the season was June 15 to October 15 and, at one time, the season opened April 15 (Holmes, correspondence on file Feb. 1973). The change of closing dates from October 15 to September 30 for the period 1962-72 may have increased

escapement by an average of 5.3 fish year^{-1} (R.S. MacLeod, pers. comm.)[4].

Estimates of the numbers of rod-days of fishing effort recorded by Conservation and Protection Branch since 1956 (Fig. 8) show a significant ($p < 0.01$) increase in 1983. Total catch is linearly and positively related ($p < 0.01$) to effort (Fig. 9). Mean yearly catch rod day^{-1} $\pm$ 95% CI for the periods 1956-1966, 1966-1970, and 1970-1983 were 0.17 $\pm$ 0.17, 0.21 $\pm$ 0.24 and 0.13 $\pm$ 0.04, while mean yearly catches were 84 $\pm$ 103, 171 $\pm$ 259 and 173 $\pm$ 132 for the same periods.

In 1983, a provincial license stub-return system was initiated to collect angling data. A total of 256 anglers who fished the North River in 1983 reported catching 191 fish (152 MSW and 37 1SW) and releasing 7 MSW and 4 1SW fish. Reported effort was 1605 rod days for a catch rod-day^{-1} of 0.12.

Sport data since 1955 indicate some disconcerting trends. In spite of the reduced seasons both total catch (Fig. 7) and effort (Fig. 8) have increased while catch unit^{-1} effort (Fig. 10) has decreased. This result can be explained by an increase in the rate of exploitation. Without augmenting or protecting the stock, increasing exploitation proximate to the spawning event can only lead to declines in egg deposition. Indeed, increasing river escapement, without management strategies to achieve target egg depositions, will likely contribute to declines in juvenile production and adult returns.

Distribution of Sport catch

Weekly catch summaries from 1973 to 1978 depict the temporal pattern of harvest during the open season of June 1-Sept. 30 (Fig. 11). The pattern for 1975 is atypical because of low water conditions and an early closure of the angling season on that portion of the river above Little Falls (Fig. 1). There was as well a closure Sept. 3 to 14, 1978, because of low water. For these reasons, a "typical" angling temporal pattern has been constructed from average weekly values for 1973, 1974, 1976 and 1977 adjusted to the weekly regime of 1976 (Fig. 11).

Observations by Conservation and Protection Branch personnel suggest that July harvests are comprised of both dark and bright fish. The latter presumably ascend the lower reaches more rapidly than their dark, earlier-arriving counterparts. By August and through September the fishery was usually concentrated in the

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[4]R.S. MacLeod, (Retired) Conservation and Protection Branch, Dept. Fisheries and Oceans, Baddeck, N.S., B0E 1A0

topmost five or six pools of the river and, with the exception of a year when low water may have impeded July entrants, is concentrated on June-July entrants. Only a few fish captured between mid-August and late September, 1978, could be classified for possible entry other than during that June-July period. Sport catches between October 1 and October 15, 1962-1972, totalled only 58 fish - 20 of which were taken in 1970. Had all October fish of 1970 been identified as late-run (there is no evidence to support this), they would only have constituted 6.9 percent of the total harvest, which is scarcely evidence of a significant fall run. Recollections by local anglers of significant fall runs prior to the 1970's may be attributed to the numbers of fall fingerlings stocked and the late run nature of the donor stocks.

Distribution of the total catch was altered in 1979 when the river above Carey's Rock (Fig. 3) was opened for hook-and-release only after July 31 and 1980-1983 when the same section was closed to angling. The proportions of the total landings taken in June, July, August and September for the years 1973, 1974, 1976 and 1977 were 32 percent, 38 percent, 22 percent, and 8 percent, respectively. In 1981 and 1982 when the closure was in effect, the respective monthly proportions of the total landings were 31 percent, 63 percent, 5 percent and 1 percent. Mean catches and SD of the two groups of years were 180 $\pm$ 47.6 and 193 $\pm$ 80.6 fish.

Spatial and temporal distributions of MSW and of 1SW fish in the sport catch, 1981 and 1982, were somewhat different (Table 7). MSW fish were caught approximately two weeks earlier than 1SW fish. However, the numbers of both sea age-classes increased with both the advancement of the season toward July 31 and the upriver progression of the fishery toward Carey's Rock Pool. Decreasing numbers were caught in the lower portions of the river later in the season.

Records of angler, date and location of capture enabled an estimate of the distribution of the sport catch among anglers for the 1982 season. Fifty-seven named and 26 unnamed anglers accounted for 217 of 250 fish reported. Anglers were limited to two fish day^{-1} of which few were released. Seasonal catch frequency, percentage of catch and percentages of catch from known anglers (Table 8) indicated that the highest proportions of the catch were accounted for by anglers taking 1, 2, 22 and 30 fish season^{-1}. Forty-six percent of successful anglers caught one or two fish. Only 2.4 percent of successful anglers had catch frequencies of 22 and 30 fish season^{-1}.

AGE COMPOSITION

Angling data for 1965 to 1983 indicate that an average 17.6 percent of the fish had returned after one winter at sea. However,

removal of the 61.8 percent value for 1981 (likely the affect of stocked fish straying from return to the nearby Middle River) reduced the mean to 14.2 percent. Analysis of the proportion 1SW fish (incl. 1981) by year indicated that the slope by least squares linear regression was different from zero ($Y = 0.59 X - 21.31$; $F = 4.41$; $p<0.10$, where X = year and Y = $\sin^{-1}$ (square root proportion). Results suggest a trend to an increasing proportion of 1SW fish in the angling catch.

Interpretation of 431 scale samples collected from the reported harvest of 1,429 fish between 1971 and 1978 indicated that 10.9 percent were 1SW fish and 89.1 percent were MSW fish (Table 9). Aging indicated that 78.3 percent had spent three years in freshwater, 14.4 percent had remained in the river for four years and 7.3 percent had spent only two years in freshwater.

The dominant life history, interpreted for 67.5 percent of the sample, was 3.2 (3 years in the river and 2 winters at sea) (Table 10). Fish of ages 4.2 and 3.1 were the next most abundant life histories with 11.6 and 8.3 percent respectively.

The freshwater age composition of the 1971-1972 samples of adult returns differed from the age composition of the samples in 1973-1978 (X^2; $p=0.01$). The difference was attributed to the decline in recent years of the relative numbers of age-4 freshwater fish. Reasons for a decrease in freshwater age of North River fish are unknown. Contributing factors may include changes in population density, environmental affects, genetics, or any combination thereof.

SEX RATIOS

Sexes were observed in 62 percent of the 1971-1978 sample - 249 for MSW fish and 20 1SW fish (Table 11). Male:female proportions were 0.072:0.928 for MSW and 0.50:0.50 for 1SW. Angling data from 1961 to 1972 when the season was open to October 15 provide little evidence of a significant fall-run of fish which might increase the proportion of males. Rivers of the Gulf of St. Lawrence, such as the Miramichi and Margaree, which support significant populations of MSW fish have exhibited male:female ratios of 14:86 for the former (Ruggles and Turner, 1973) and 25:75 for the latter (Marshall, MS 1982). In each instance 1SW fish were comprised of more males - 78 percent on the Miramichi and 89 percent on the Margaree. Barring biases in the North River samples, one might hypothesize that every escaping male is critical to the success of spawning and that precocious male parr may well contribute to stock reproduction.

IN-RIVER EXPLOITATION RATES

Salmon runs to the North River have never been trapped and counted, but estimates were made by personnel of the Conservation and Protection Branch in 1974, 1975 and 1978 of the number of salmon remaining in the river during low water periods of August-September, likely reflecting the portion of the river entrants escaping to spawn. The clarity of the water, the limited number and size of the holding pools, and the years of experience among the staff as to the location of the fish all contribute to the validity (accuracy) of these estimates. Estimates of remaining salmon and angler harvests provide rates of exploitation or, conversely, rates of spawning escapement, assuming that there were no significant fall runs. Escapements in 1974, 1975 and 1978 were estimated at 45, 80 and 45 fish, respectively, and represent about 15, 41 and 17 percent of fish thought to have entered the river. In-river exploitation rates were, then, in the order of 0.85, 0.59 and 0.83.

In-river exploitation rates previous to 1979 likely approached the 0.84 average of 1974 and 1978 when angling, unlike 1975, was not affected by partial closure. If 1973, 1974, 1976 and 1977 were normal years with an average sport yield of 189 fish, as few as 36 fish may have been left to spawn in those years.

SPAWNING REQUIREMENTS

Total estimated egg requirements for the $3,559*10^2$ m^2 of North River rearing area range between 605 and $854*10^3$ eggs. Egg depositions $fish^{-1}$ of 238 for 1SW and 3,529 for MSW fish were calculated as follows:

Sea-age	Eggs kg^{-1}	Prop. female	Mean weight (kg)	Prop. salmon or grilse	Egg deposition $fish^{-1}$
MSW	1,343	0.928	3.3	0.858	3,529
1SW	1,764	0.501	1.9	0.142	238
Total					3,767

The required spawning escapement to seed the North River is estimated to range from 160 to 227 fish (the division of egg requirement by eggs $fish^{-1}$). At current 1SW:MSW ratios, 137 to 195 MSW fish and 23 to 32 1SW fish are necessary to meet spawning requirements.

ACHIEVING TARGET SPAWNING ESCAPEMENTS

Minimum target spawning escapements for North River will not be met without a decrease in stock exploitation. A reduced harvest in the St. Ann's Harbour commercial fishery would be the most effective means to increase numbers of river entrants. Reduction of commercial harvests in June in FSD Nos. 1 and 4 would achieve similar results.

Increasing the number of river entrants would not improve spawning escapements unless potentially increasing angler exploitation rates were curtailed. This fact is emphasized by the increasing angling effort and by the significant relationship between increasing catch and effort in the sport fishery (Fig. 9).

Management strategies to reduce exploitation by angling involve reductions in creel limits or the manipulation of angling seasons or areas. Creel data collected in 1981 and 1982 (351 samples) indicated that 22 anglers caught two fish day^{-1} on 43 occasions and at least 37 anglers caught two or more fish $week^{-1}$. In 1982, four anglers caught five or more fish $week^{-1}$ during six weeks of the season.

A reduction in daily creel limit from two to one fish day^{-1} would have saved 21 fish (6 percent of the sample) for possible capture by the same party on another day or week, by another party or for spawning escapement. Given the effort and catch trends for the North River, the possibility of capture is most likely.

A season limit such as 15 fish (1983) would have had the effect of saving for similar fates two fish in 1981 and 25 fish in 1982. A season limit of ten fish may have saved or redistributed seven fish in 1981 and 47 in 1982.

Other strategies to increase spawning escapement such as shortening the angling season and/or restricting fishing to a particular area of the river were also studied. Carey's Rock (Fig. 2) has been suggested as a practical point above which the river could be closed to fishing to provide sanctuary for the desired escapement.

To define the potential savings of instituting various closure dates above Carey's Rock, the 1972-1978 angling data and information accompanying scale samples were reexamined. Samples from 1973 and 1978 provided the most complete information on locations of capture and were tested for non-difference in the weekly catch distribution (X^2; $p=0.05$) of the combined 1973-1978 data and the "normal" angling pattern (omitting 1975 and 1978 because of closures). Capture data suggested that 189 fish were angled in a "normal" season and were

distributed similar to the pooled capture data adjusted to a 1978 weekly angling regime.

The estimated number of fish angled above and below Carey's Rock up to five arbitrarily selected dates, July 15th through September 1, are provided in Table 12. The effective harvest below Carey's Rock is 86.9 percent complete by July 15 and 100 percent complete by August 27. Above Carey's Rock the harvest is 28.8 percent and 91.0 percent complete on the same dates. Savings gained by a closure above Carey's Rock range from six fish after August 26 to 47 fish after July 15 (Table 13) and would reduce the total catch by 3.2 and 24.9 percent respectively. The latter would double potential spawning escapement from 47 to 94 fish - still short of the estimated requirement. However, it is recognized that a short season, i.e., June 1 to July 15, may serve to concentrate fishing pressure and thereby increase exploitation such that escapement might not be better than that achieved by closures on July 30 or August 16. Either of these latter dates, particularly August 16 if applied to the entire river would; (1) increase escapement by 28 fish (57 percent), (2) assure through the 1SW component the escapement of an increased number of males, and (3) reduce the angler harvest by only 15 percent.

A variation order closing the area above Carey's Rock after July 31 has been implemented each year since 1979. Broodstock collections in MacLean's pool in 1982 and 1983 enabled divers to observe 30 to 40 and 70 to 80 fish in that one pool in respective years. Small numbers of fish were also observed in Oregon Run above MacLean's in 1983. Fishery officers reported few fish in MacLeod's pool in late 1982 and approximately 15 fish in 1983. Thus, it would appear that in spite of the closure, escapements in both 1982 and 1983 were low relative to requirements. It is interesting to note that the sport catch of 250 fish (154 MSW, 96 1SW) in 1982 was the highest up to 1984. The 1983 sport catch of 86 fish (69 MSW, 17 1SW) in a shortened season (closure from June 2 to July 2) was the lowest since 1966. While illegal removals may have occurred above Carey's Rock in 1982, it is doubtful these were of a magnitude to account for the apparent paucity of spawners. Clearly, protection of the fish remaining in the closed area, after being subject to the angling fishery, should remain a priority.

Continued protection of the potential spawners, increasing river entrants and curtailing increasing exploitation rates by the sport fishery are primary areas for improved management of the North River salmon resource.

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Table 1. Area (m^2*100) by percent orthogradient and distance above the 10-m contour for the North River, Vic. Co.

Dist. interval (km)	Orthogradient interval 0-0.12	0.121-0.249	0.25-0.49	0.5-.99	1-1.49	1.5-1.99	2-2.49	2.5-2.9	3-3.49	3.5-5.0	>5.0	Row totals	Row percents of total area
00-10.00	0	0	391	873	970	83	96	6	11	38	25	2,492	70.0
10.001-20	0	0	0	26	266	106	137	115	187	113	9	959	26.9
20.001-30	0	0	0	56	40	11	0	0	0	0	0	108	3.0
Column totals	0	0	391	955	1,277	201	233	121	198	151	33	3,559	100.0
Column percents of total area	0.0	0.0	11.0	26.8	35.9	5.7	6.6	3.4	5.6	4.2	0.9		

Table 2. Densities (10^{-2} m^2) of Atlantic salmon, brook trout and American eels at three electrofishing sites on the North River, August 1978.

Site	Numbers of salmon Fry	Age 1+	Age 2+	Age 3+	Numbers of trout Fry	Older	Numbers of eels
Below hwy	29.3	5.7	0.5	0.0	0.7	0.2	42.9
Hwy to gorge	14.4	9.4	2.3	0.5	0.3	0.0	34.7
Above gorge	107.5	25.8	6.4	0.0	1.9	3.7	trace[1]

[1] Observed but not caught.

Table 3. Age and sex of 12 and 79 Atlantic salmon taken from June 12 to July 3, 1975, and May 13 to June 27, 1978, respectively and combined as sampled from commercial salmon traps set in St. Ann's Harbour.

Age and sex	1975		1978		Total	
	No.	%	No.	%	No.	%
Freshwater age						
2 years	3	25.0	17	21.5	20	22.0
3 years	8	66.7	57	72.1	65	71.4
4 years	1	8.3	5	6.3	6	6.6
Sea-age						
1 year			1	1.3	1	1.1
2 years	10	83.3	68	86.1	78	85.7
3 years	2	16.7	10	12.7	12	13.2
Sex						
Male	2	16.7	10	12.7	12	13.2
Female	10	83.3	69	87.3	79	86.8

Table 4. Age of 12 and 79 Atlantic salmon taken June 12 to July 3, 1975, and May 31 to June 27, 27, 1978, respectively and combined as sampled from commercial salmon traps set in St. Ann's Harbour (indicates) percent of yearly sample.

Year	Age (Freshwater - Saltwater)						
	2.2	2.3	3.1	3.2	3.3	4.2	4.3
1975	2 (16.7)	1 (8.3)		7 (58.3)	1 (8.3)	1 (8.3)	
1978	11 (13.9)	6 (7.6)	1 (1.3)	54 (68.3)	2 (2.5)	3 (3.8)	2 (2.5)
Combined	13 (14.3)	7 (7.7)	1 (1.1)	61 (67.0)	3 (3.3)	4 (4.4)	2 (2.2

Table 5. Number of M-SW and 1-SW Atlantic salmon reported landed by the North River, Victoria County, sport fishery complete with effort in rod- days for the years 1951 to 1983.

	Number of Angled Fish			
Year	M-SW	1-SW	Total	Rod-days
1951			140	375
1952			356	949
1953			177	1397
1954			198	13856
1955			81	8625
1956			91	435
1957			27	400
1958			45	236
1959			162	975
1960			52	307
1961			67	481
1962			145	1100
1963			63	589
1964			59	374
1965	133	14	147	670
1966	60	2	62	172
1967	120	12	132	865
1968	112	14	126	748
1969	168	79	247	1416
1970	252	38	290	1570
1971	149	22	171	1318
1972	158	13	171	1365
1973	133	19	152	1355
1974	222	25	247	1780
1975	91	24	115	850
1976	128	20	148	1125
1977	162	47	209	1615
1978	206	10	216	1690
1979	87	17	104	725
1980	108	20	128	990
1981	52	84	136	1224
1982	154	96	250	1580
1983	69	17	86	826

Table 6. Mean annual catches and trends as indicated by regressions of total catch on year for the periods 1929-38, 1938-1966, 1966-1970, and 1970-1983 for North River, Victoria County.

Period	Mean catch $\bar{x}$	Std. error of $\bar{x}$	Regression terms		F-value	
			Coefficient	Constant	Calc.	F.05
1929-38	126.1	41.3	39.3	-1,188.9	38.3	5.32
1938-66	166.2	17.5	-8.5	608.2	38.6	4.21
1966-70	171.4	42.0	57.1	-3,711.4	35.5	10.10
1970-83	173.1	16.3	-5.8	613.07	2.2	4.75

Table 7. Temporal and spatial distribution of percentage M-SW salmon and 1-SW grilse angled in the North River, Victoria Co., for 1981 + 1982 combined. (n = 220 salmon, 131 grilse).

Dates	Church to Little Run		Black to Eleanor		Carey's Rock to Camp		Totals	
	Salmon	Grilse	Salmon	Grilse	Salmon	Grilse	Salmon	Grilse
June 1-15	6.4	0.0	4.5	0.8	0.0	0.0	10.9	.8
June 16-30	11.4	15.3	11.8	6.2	0.9	0.0	24.5	21.4
July 1-15	6.4	8.3	9.0	16.8	16.0	4.6	29.7	29.8
July 16-31	2.3	4.6	4.5	18.4	21.7	15.3	38.3	38.2
Aug 1-15	0.5	0.8	2.7	6.1	CLOSED		6.9	6.9
Aug 16-31	0.0	0.0	0.5	1.6	TO		1.6	1.5
Sept 1-15	1.0	0.8	0.0	0.8	ANGLING		1.6	1.5
Sept 16-30	0.5		0.0				0.0	0.0
Total Salmon	28.5		33.0		38.6			
Total Grilse		29.8		50.7		19.9		

Table 8. Atlantic salmon catch frequency for "known" anglers of 217 fish captured in the North River Vic. Co., 1982.

Catch Frequency	Anglers		Percent of Catch
	No.	Percent	
1	26	31.3	10.4
2	12	14.5	9.6
3	4	3.6	3.6
4	3	3.6	4.8
5	1	1.2	2.0
6	3	3.6	7.2
8	1	1.2	3.2
9	2	2.4	7.2
12	1	1.2	4.8
16	1	1.2	6.4
17	1	1.2	6.8
22	1	1.2	8.8
30	1	1.2	12.0

Table 9. Freshwater and sea age composition as determined from scales of 431 salmon sampled in the North River sport fishery, 1971-1978. Parentheses indicate percentages within freshwater and marine age groups.

Year of Sample	Freshwater age				Sea age					Total Sample
	2	3	4	?	1	2	3	repeat	?	
1971	2 (2.5)	61 (76.3)	17 (21.3)		4 (5.1)	72 (92.3)	3 (3.8)	1 (1.3)		80
1972	3 (3.7)	55 (67.1)	24 (29.3)	2	4 (4.8)	76 (90.5)	2 (2.4)	2 (2.4)		84
1973	15 (21.4)	47 (67.1)	8 (11.4)		12 (17.1)	56 (80.0)	1 (1.4)	1 (1.4)		70
1974		38 (92.7)	3 (7.3)	1	10 (24.4)	31 (75.6)			1	42
1975	5 (13.9)	28 (77.8)	3 (8.3)		5 (13.9)	31 (86.1)				36
1976		23 (88.5	3 (11.5)	1	2 (7.4)	25 (92.6)				27
1977	6 (15.4)	31 (79.5)	2 (5.1)	1	8 (20.0)	32 (80.0)				40
1978		48 (98.0)	1 (2.0)	3	2 (3.9)	49 (94.2)		1 (1.9)		52
Total (mean)	31 (7.3)	331 (78.3)	61 (14.4)	8	47 (10.9)	372 (86.5)	6 (1.4)	5 (1.2)	1	431

Table 10. Age (year) composition as determined from scales of 431 Atlantic salmon sampled in the North River sport fishery, 1971- 1978. Parenthesis indicates percentages of annual sample.

Year of Sample	Age (Freshwater . Seawinters)											Sample
	2.1	2.2	2.r	3.1	3.2	3.3	3.r	4.1	4.2	4.r	?.2	
1971		2 (2.5)		1 (1.3)	56 (70.0)	3 (3.8)	1 (1.3)	3 (3.8)	14 (17.5)			80
1972	1 (1.2)	2 (2.4)		1 (1.2)	51 (60.7)	2 (2.4)	1 (1.2)	2 (2.4)	21 (25.0)	1 (1.2)	2 (2.4)	84
1973		14 (20.0)	1 (1.4)	11 (15.7)	35 (50.0)	1 (1.4)		1 (1.4)	7 (10.0)			70
1974				7 (16.7)	30 (71.4)			3 (7.1)			2 (4.8)	42
1975		5 (13.9)		5 (13.9)	23 (63.9)				3 (8.3)			36
1976					23 (85.2)			2 (7.4)	1 (3.7)		1 (3.7)	27
1977		6 (15.0)		8 (20.0)	22 (55.0)		1 (2.5)		2 (5.0)		1 (2.5)	40
1978				2 (3.8)	45 (86.5)		1 (1.9)		1 (1.9)		3 (5.8)	52
Total and overall percent	1 (0.2)	29 (6.9)	1 (0.2)	35 (8.3)	285 (67.5)	6 (1.4)	4 (1.0)	11 (2.6)	49 (11.6)	1(0.2)	9 (2.1)	431

Table 11. Number and percentage () of male and female Atlantic salmon identified in the North River sport fishery, 1971 - 1978.

Year	1-Sea-Winter		2+-Sea-Winter		Total
	Male	Female	Male	Female	
1971	0	2 (100.0)	2 (2.7)	71 (97.3)	75
1972	0	0	4 (9.1)	40 (90.9)	44
1973	4 (66.7)	2 (33.3)	2 (13.3)	13 (86.7)	21
1974	0	1 (100.0)	0	10 (100.0)	11
1975	3 (75.0)	1 (25.0)	3 (14.3)	18 (85.7)	25
1976	0	2 (100.0)	1 (5.0)	19 (95.0)	22
1977	2 (66.6)	1 (33.3)	4 (17.4)	19 (82.6)	26
1978	1 (50.0)	1 (50.0)	2 (4.7)	41 (95.3)	45
Total	10 (50.0)	10 (50.0)	18 (7.2)	231 (92.8)	269

Table 12. Cumulative numbers and percentages () of salmon angled until specific dates below and above Carey's Rock, North River, during a "normal" angling season (See text for derivation of "normal").

Closure dates	Carey's Rock				Total for river	
	Below		Above			
	1-SW	M-SW	1-SW	M-SW	1-SW	M-SW
July 16	4 (3.2)	103 (83.7)		19 (28.8)	4 (2.1)	122 (64.6)
July 30	4 (3.2)	112 (91.1)		21 (31.8)	4 (2.1)	133 (70.4)
Aug 16	4 (3.2)	112 (91.1)	6 (9.1)	39 (59.1)	10 (5.3)	151 (79.9)
Aug 27	11 (8.9)	112 (91.1)	6 (9.1)	54 (81.9)	17 (9.0)	166 (87.8)
Oct 1	11 (8.9)	112 (91.1)	6 (9.1)	60 (90.9)	17 (9.0)	172 (91.0)
Totals to October 1	123		66		189	

Table 13. Savings in number and percentage () of 189 salmon angled in a "normal" year for spawning escapement by closure to angling above Carey's Rock and of the total North River on various dates between July 16 and October 1.

Closure dates	Above Carey's Rock		Total for river	
	1-SW	M-SW	1-SW	M-SW
July 16	6 (3.2)	41 (21.7)	13 (6.9)	50 (26.5)
July 30	6 (3.2)	39 (20.6)	13 (6.9)	39 (20.6)
Aug 16	0	21 (11.1)	7 (3.7)	21 (11.1)
Aug 27	0	6 (3.2)	0	6 (3.2)
Oct 1	0	0	0	0

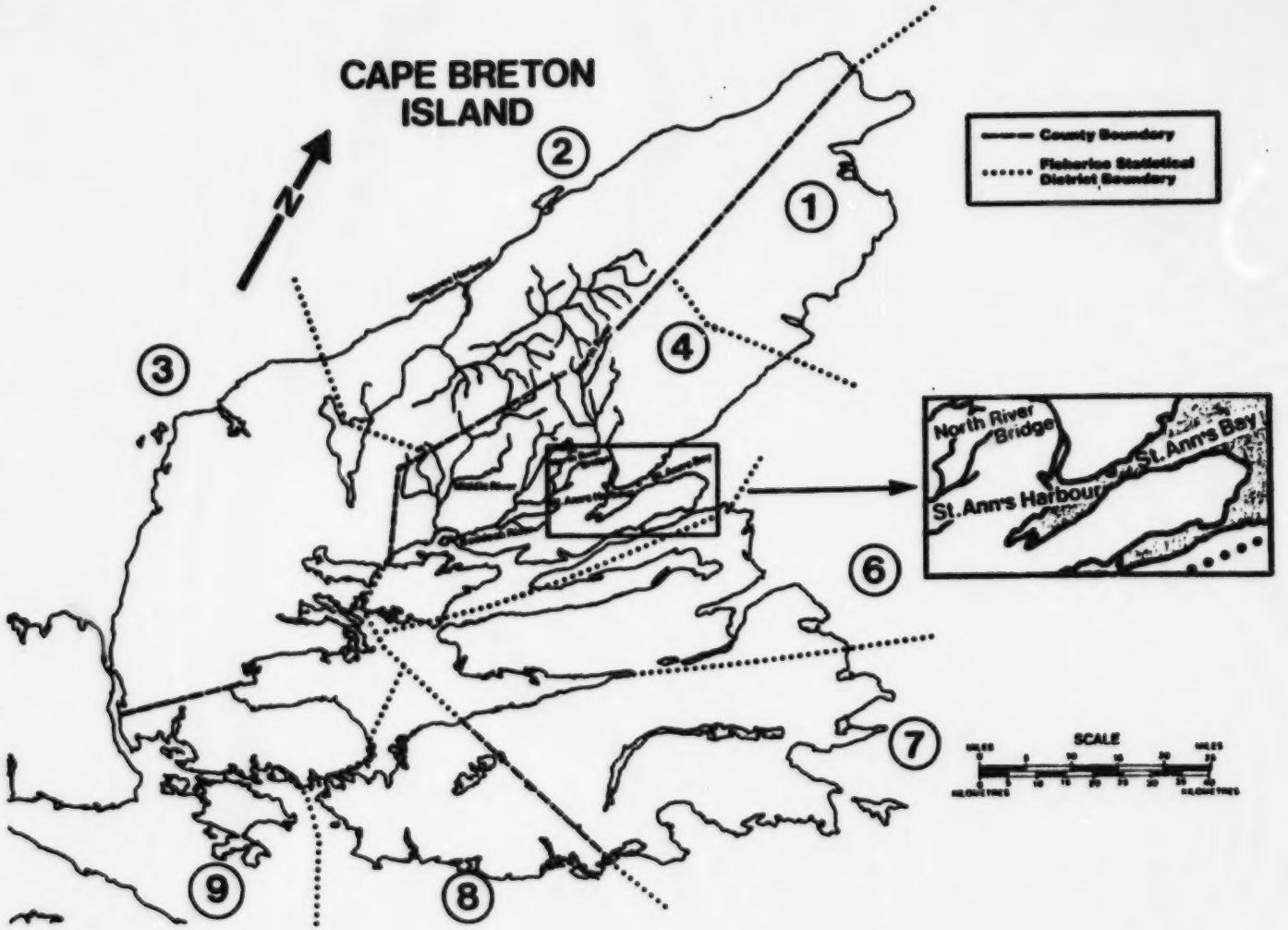

Fig. 1. Map of Cape Breton Island with enlargement of St. Ann's Bay and Harbour.

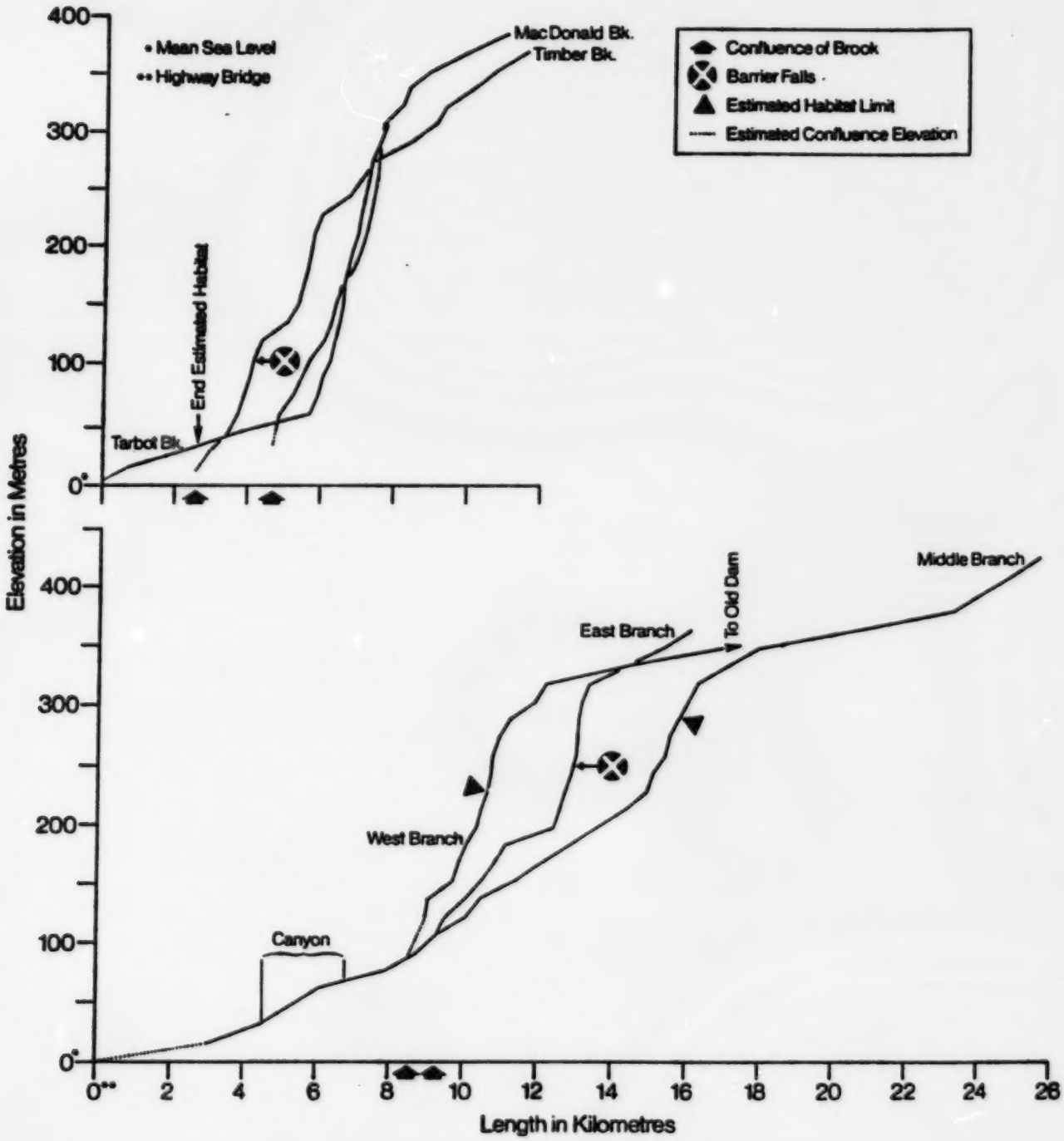

Fig. 2. Longitudinal profiles of the North River and tributaries showing locations of barriers, habitat limits and confluences. (Data measured from topographic maps).

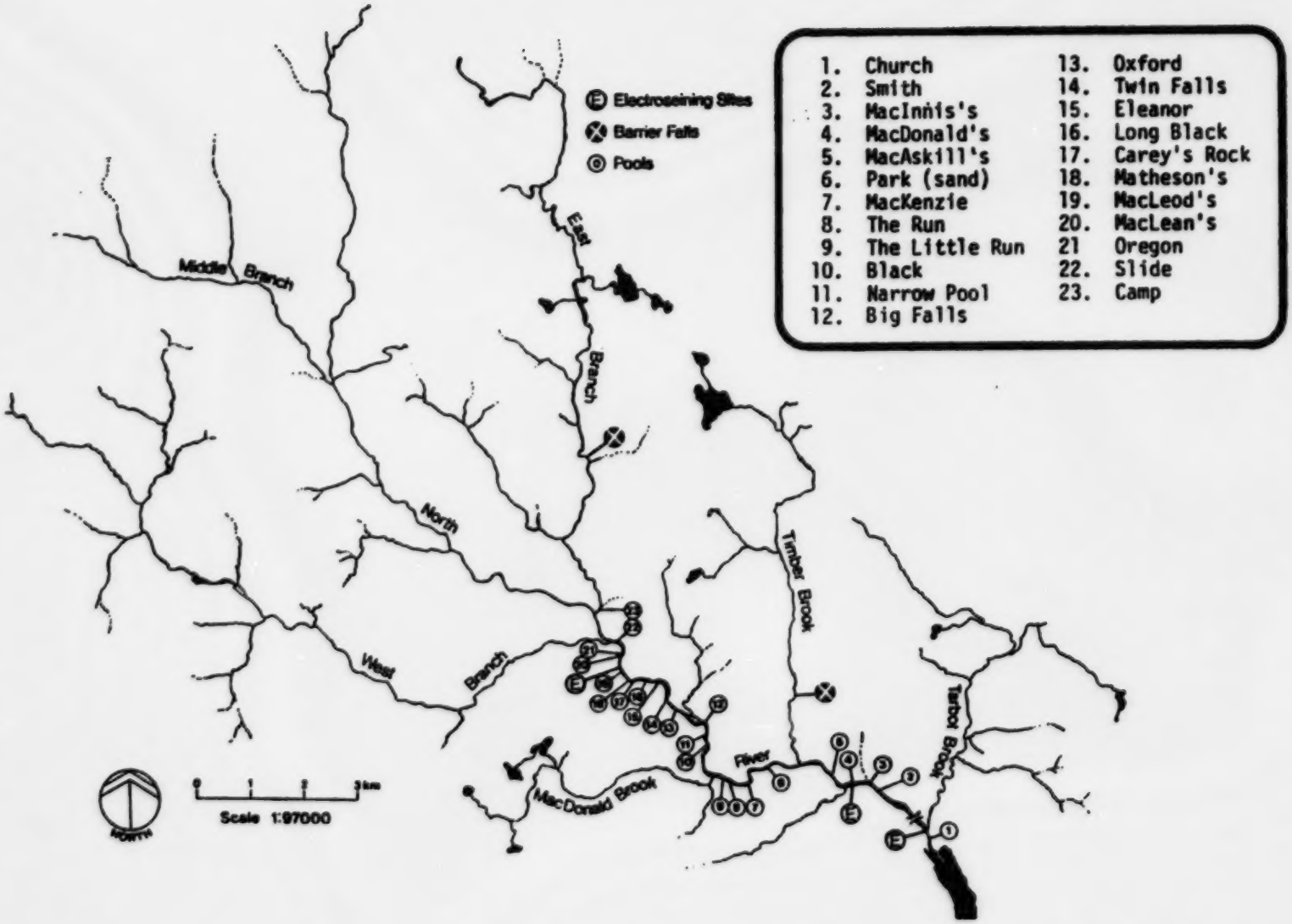

Fig. 3. Map of North River, Victoria County showing name and locations of angling pools.

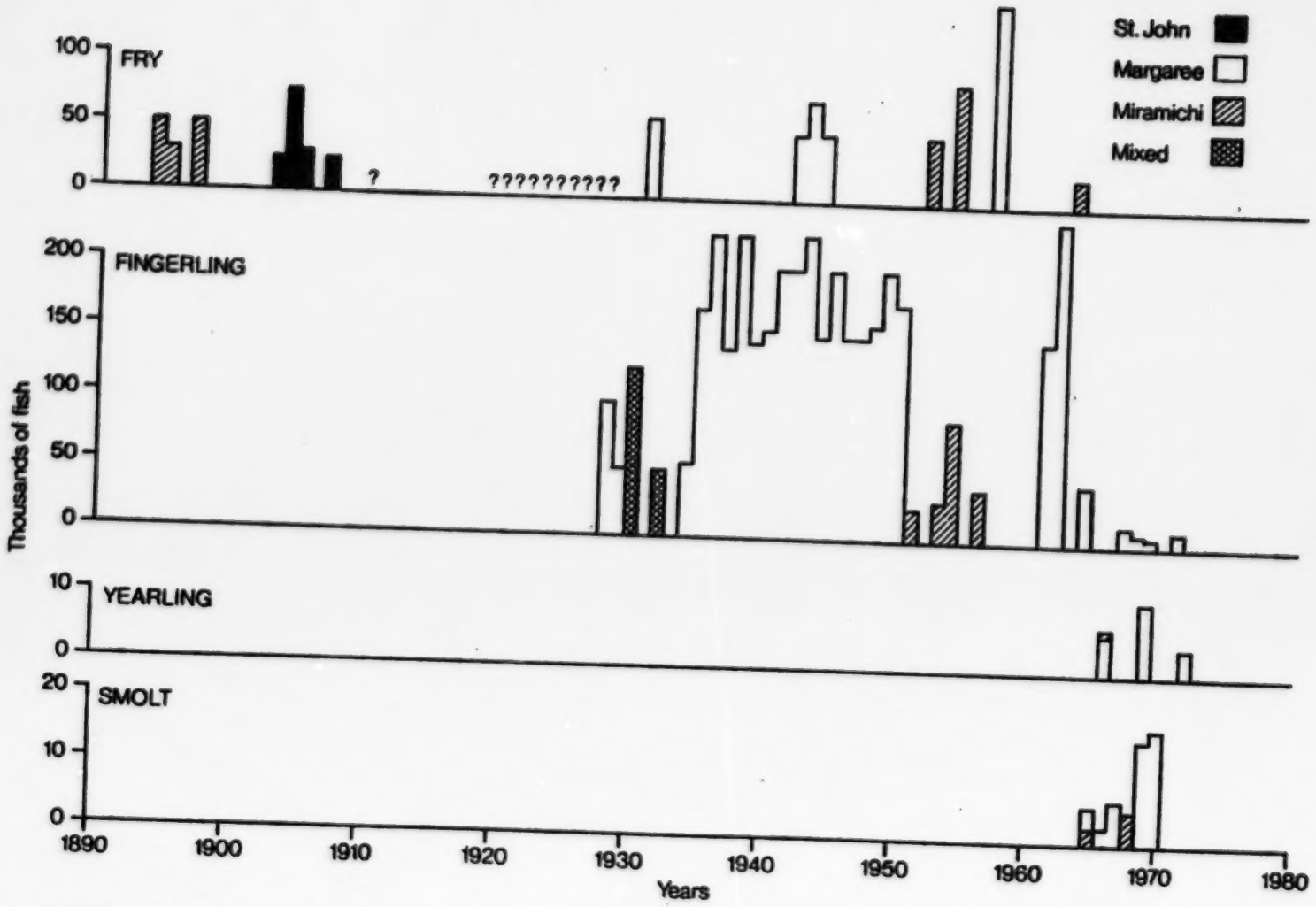

Fig. 4. Numbers $X10^3$ of fry, fingerlings, yearlings and Atlantic salmon smolts recorded and released into the North River from 1890 to 1980.

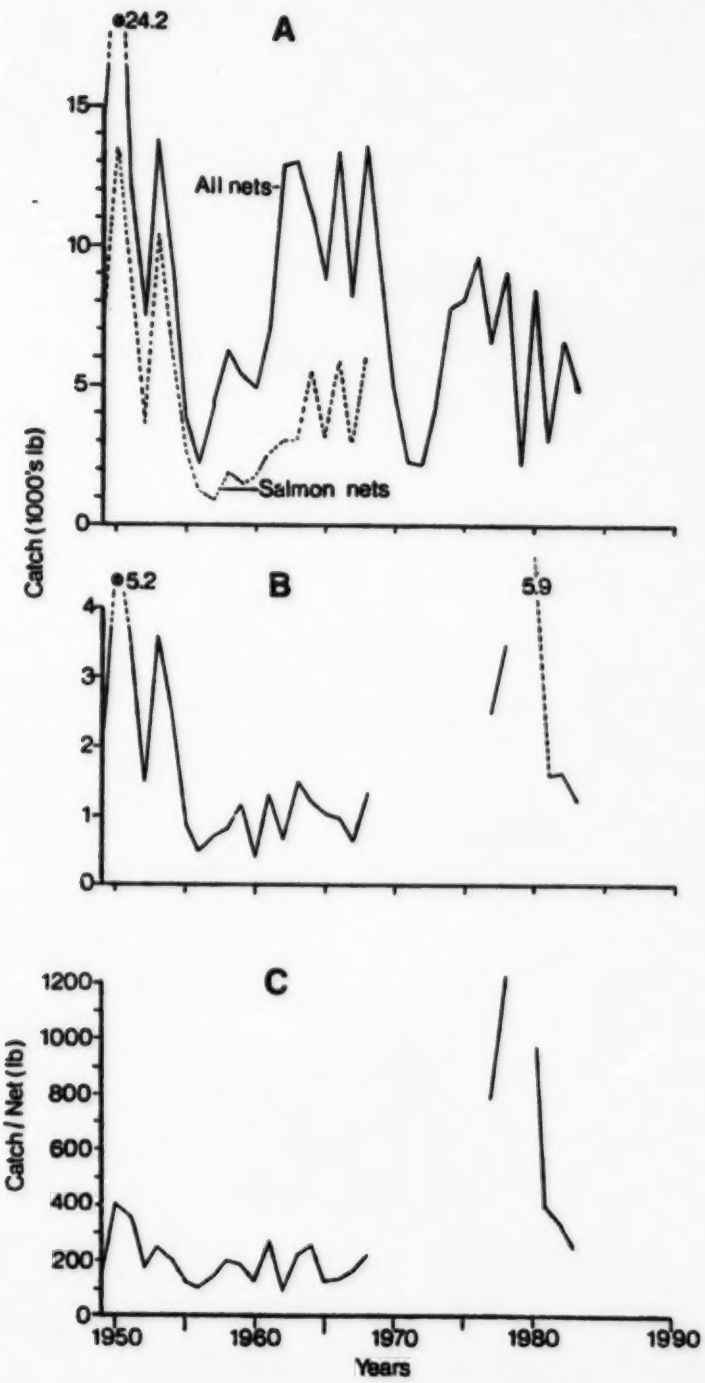

Fig. 5. Atlantic salmon catches reported for Fisheries Statistical District No. 4 from 1950 to 1984 (A), for St. Ann's Bay salmon traps (B), and catch per trap for St. Ann's Bay (C), 1950-1983.

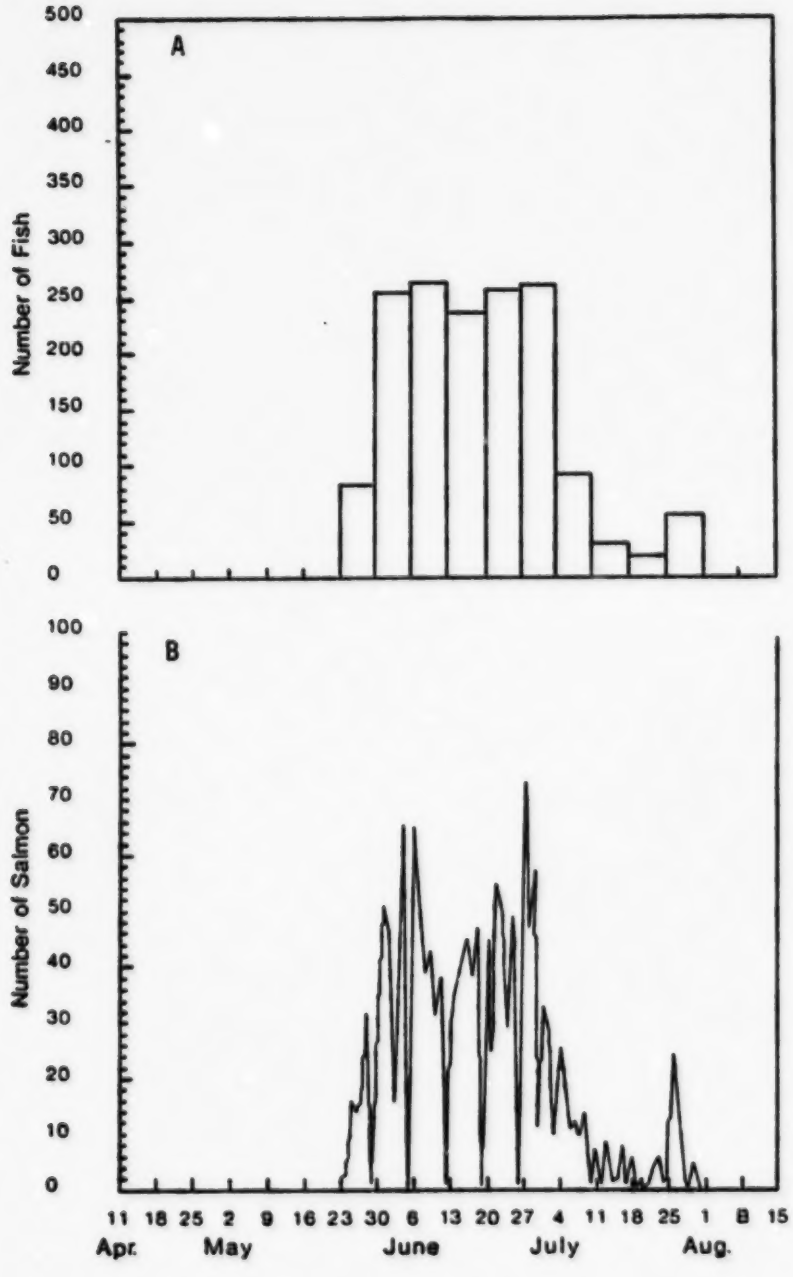

Fig. 6. Weekly (A) and daily (B) landings of Atlantic salmon captured in St. Ann's Bay commercial salmon fishery from 1980 to 1983 adjusted to 1983 weekly regime.

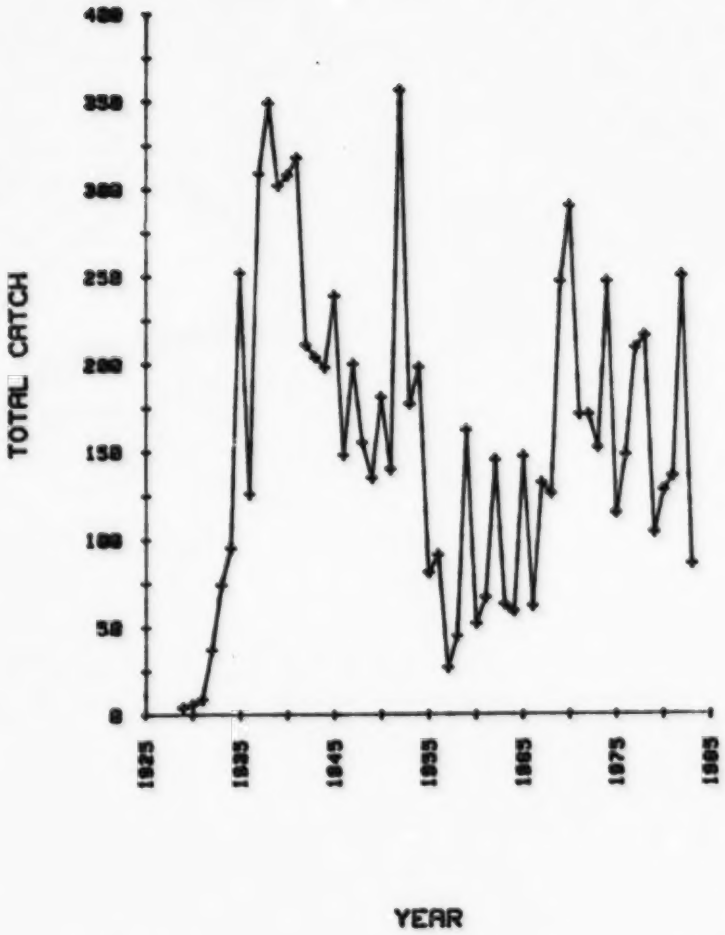

Fig. 7. Number of Atlantic salmon reported caught in the North River sport fishery, 1929 to 1983.

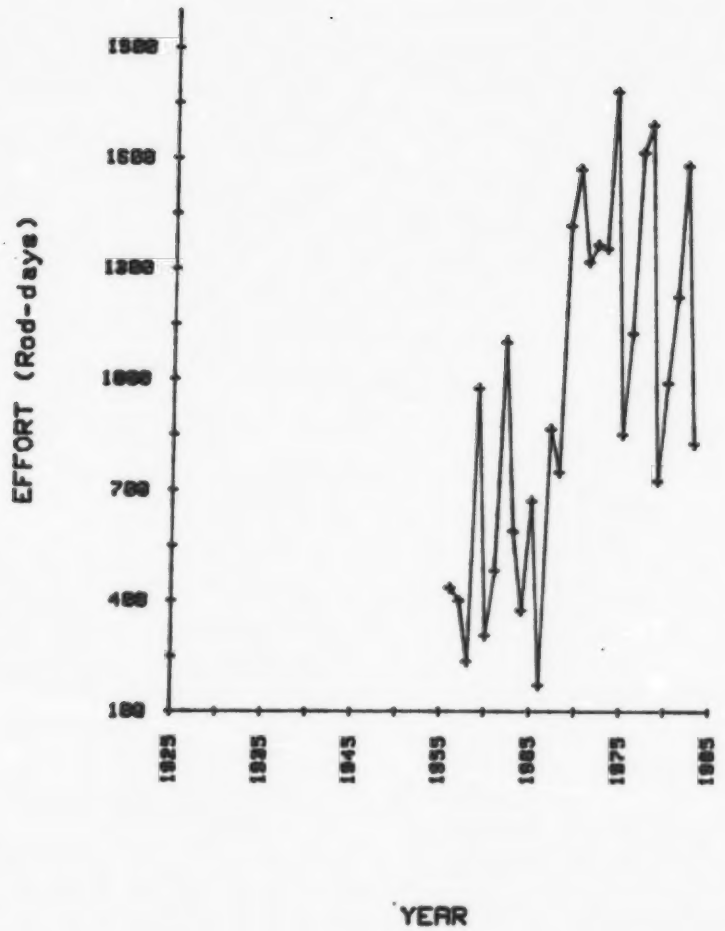

Fig. 8. Effort in rod-days for the North River sport fishery, 1956 to 1983.

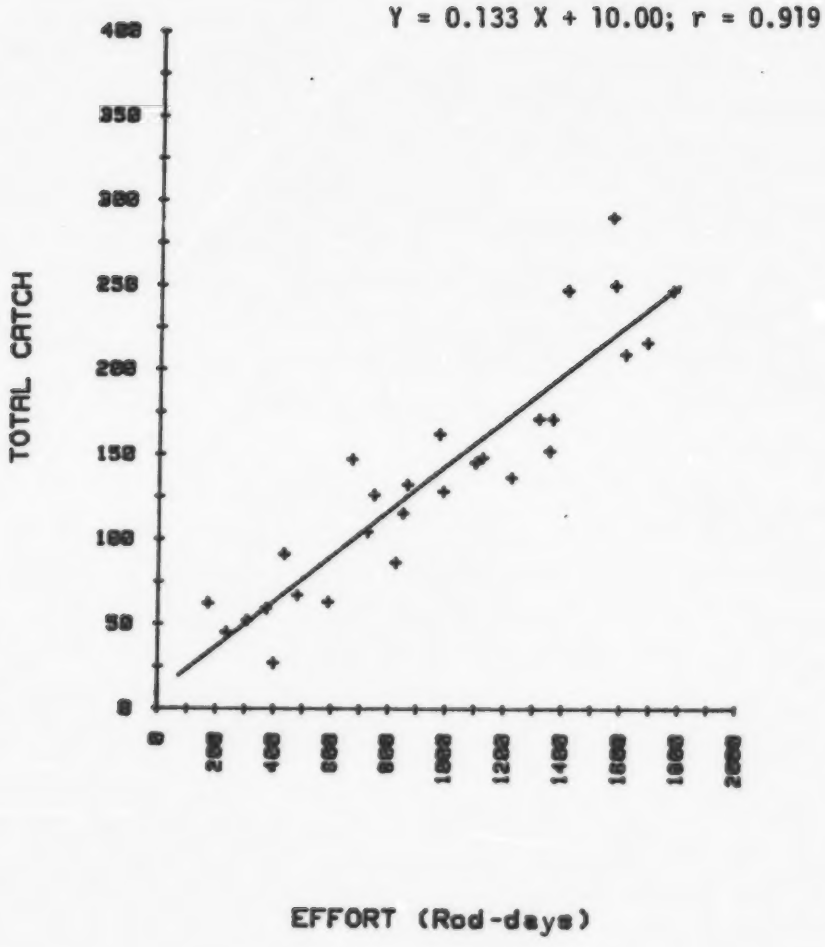

Fig. 9. Relationship between total catch of Atlantic salmon and effort for the North River sport fishery for the period 1956 to 1983.

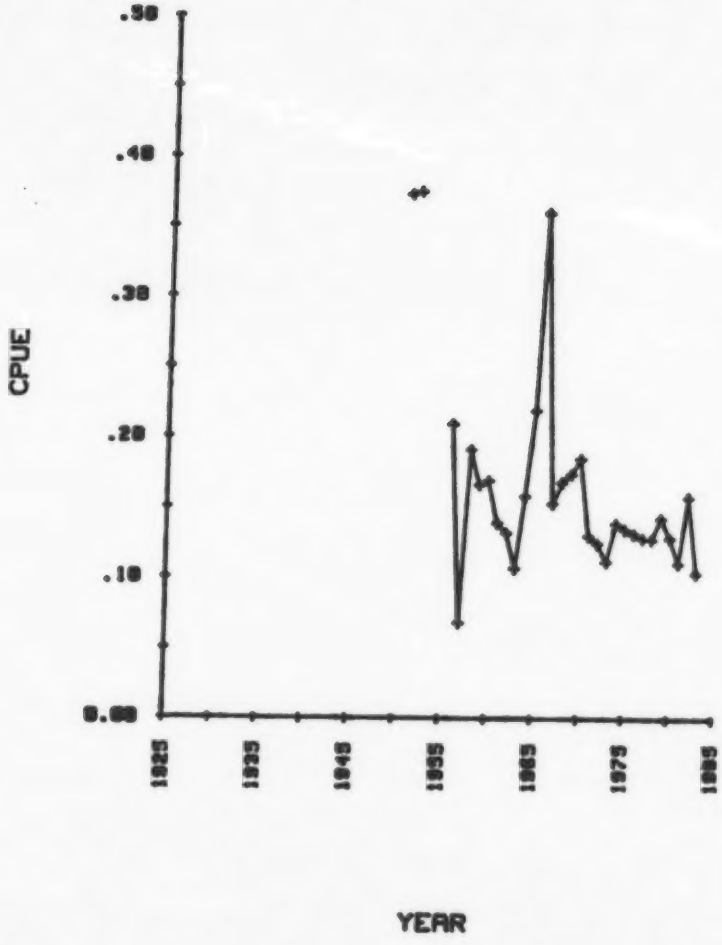

Fig. 10. Annual catch of Atlantic salmon per unit of effort (Rod-days) for the North River sport fishery, 1953 to 1983.

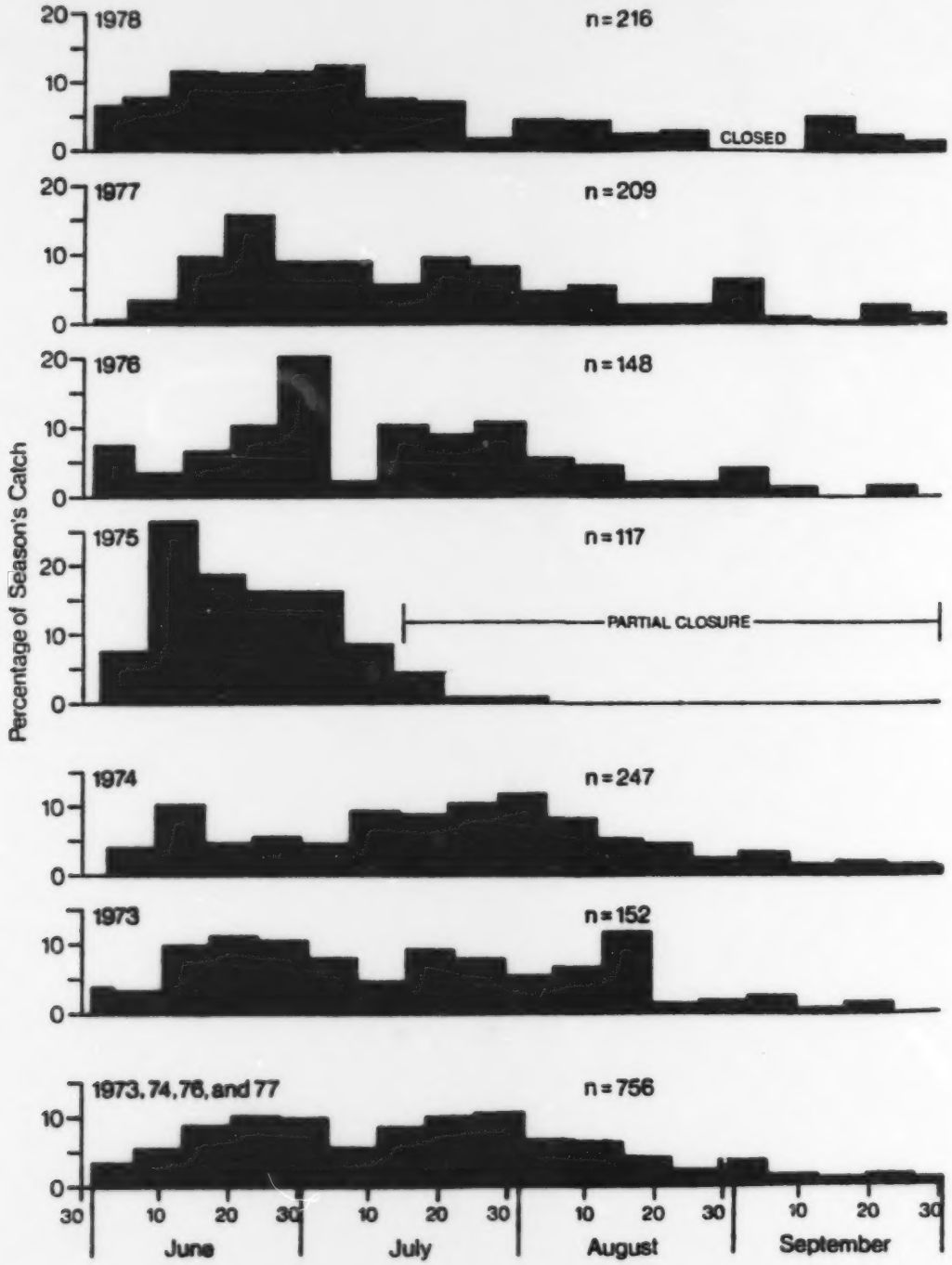

Fig. 11. Weekly catch of Atlantic salmon as percentage of season's catch for the North River sport fishery, 1973 to 1978, adjusted to the weekly regime of 1976.